

WHAT IS CLAIMED IS:

- 1 1. Apparatus for use at a node of an optical fiber ring network, comprising:
2 at least one link card that sends and receives a data stream to and from a client device;
3 a least one multiplexer unit that sends and receives data streams to and from at least
4 first and second optical fiber cables; and
5 switching apparatus for interconnecting the multiplexer units to the link cards;
6 each multiplexer unit including a coarse optical wavelength division multiplexer and
7 demultiplexer that sends a first data stream over the first optical fiber cable using a first
8 optical wavelength and that receives a second data stream from the first optical fiber cable at
9 a second optical wavelength, where the first and second optical wavelengths differ by at least
10 10 nm.
- 1 2. The apparatus of claim 1, wherein the coarse optical wavelength division multiplexer
2 and demultiplexer sends a third data stream over the second optical fiber cable using the
3 second optical wavelength and receives a fourth data stream over the second optical fiber
4 cable at the first optical wavelength.
- 1 3. The apparatus of claim 1, wherein each link card includes an inbound FIFO frame
2 buffer with memory capacity for storing at least 120 Fibre Channel frames sent by the client
3 device to the link card and an outbound FIFO frame buffer with memory capacity for storing
4 at least 120 Fibre Channel frames sent by another device to the link card for transmission to
5 the client device.
- 1 4. The apparatus of claim 3, wherein each link card includes circuitry that exchanges
2 buffer credit signals with another link card coupled thereto by one of the first and second
3 optical fiber cables so as to pre-fill the outbound FIFO frame buffer with frames of data
4 before the client device sends flow control messages to request the transmission of those data
5 frames by another client device coupled to the other link card.

1 5. The apparatus of claim 3, wherein each link card includes flow control circuitry for
2 pre-filling the outbound FIFO frame buffer with frames of data before the client device sends
3 flow control messages to request the transmission of those data frames.

1 6. The apparatus of claim 1, wherein
2 each link card includes an inbound FIFO frame buffer that stores frames sent by the
3 client device to the link card and an outbound FIFO frame buffer that stores frames sent by
4 another device to the link card for transmission to the client device; and
5 the link card stores data into the inbound FIFO frame buffer and reads data from the
6 outbound FIFO frame buffer at a first clock rate associated with the client device, and reads
7 data the inbound FIFO frame buffer for transmission to the multiplexer unit and stores data
8 received from the multiplexer unit into the outbound FIFO frame buffer at a second clock rate
9 associated with the link card, whereby the data stream sent and received to and from the client
10 device is retimed from the first clock rate to the second clock rate.

1 7. The apparatus of claim 6, wherein the data stream sent and received to and from the
2 client device is a Fibre Channel data stream, the first clock rate is approximately 1.0625
3 Gbps, and the second clock rate is at least 1.25 Gbps.

1 8. The apparatus of claim 6, wherein the multiplexer unit includes a smoothing circuit
2 that retimes the data stream sent from the client device from the second clock rate to a third
3 clock rate associated with the multiplexer unit, the multiplexer unit transmitting the data
4 stream over one of the first and second optical fiber cables at the third clock rate.

1 9. Apparatus for use at a node of an optical fiber ring network, comprising:
2 a first link card that sends and receives first and second data streams to and from a
3 client device;
4 a second link card that sends and receives third and fourth data streams to and from
5 the client device;
6 a first multiplexer unit that merges the first and third data streams into a first
7 combined data stream and transmits the first combined data stream over a first optical fiber

8 cable, and that receives a second combined data stream from the first optical fiber and
9 extracts the second and fourth data streams from the second combined data stream; and
10 switching apparatus for interconnecting the first multiplexer unit to the first and
11 second link cards;
12 the first multiplexer unit including a coarse optical wavelength division multiplexer
13 and demultiplexer that sends the first combined data stream over the first optical fiber cable
14 using a first optical wavelength and receives the second combined data stream from the first
15 optical fiber cable at a second optical wavelength, where the first and second optical
16 wavelengths differ by at least 10 nm.

1 10. The apparatus of claim 9, wherein the first and second data streams are Fibre Channel
2 data streams and the third and fourth data streams are Gigabit Ethernet data streams.

1 11. The apparatus of claim 9, wherein one of the first multiplexer unit and the first link
2 card includes circuitry that inserts into the first data stream, prior to the first data stream being
3 merged with the third data stream, marking symbols for marking the first data stream so as to
4 enable a receiving device that receives the first combined data stream to identify the first data
5 stream within the first combined data stream.

1 12. The apparatus of claim 11, wherein the first multiplexer unit includes a demultiplexer
2 that demultiplexes the second combined data stream into the second and fourth data streams
3 and that identifies the second data stream by identifying instances of the marking symbols in
4 the second combined data stream.

1 13. The apparatus of claim 9, wherein the coarse optical wavelength division multiplexer
2 and demultiplexer sends a third combined data stream over the second optical fiber cable
3 using the second optical wavelength and receives a fourth combined data stream over the
4 second optical fiber cable at the first optical wavelength.

1 14. The apparatus of claim 9, wherein the first and second link cards each include an
2 inbound FIFO frame buffer with memory capacity for storing at least 120 Fibre Channel
3 frames sent by the client device to the link card and an outbound FIFO frame buffer with

4 memory capacity for storing at least 120 Fibre Channel frames sent by another device to the
5 link card for transmission to the client device.

1 15. The apparatus of claim 14, wherein the first and second link cards each include
2 circuitry for exchanging buffer credit signals with another link card coupled thereto by one of
3 the first and second optical fiber cables so as to pre-fill the outbound FIFO frame buffer with
4 frames of data before the client device sends flow control messages to request the
5 transmission of those data frames by another client device coupled to the other link card.

1 16. The apparatus of claim 14, wherein the first and second link cards each includes flow
2 control circuitry for pre-filling the outbound FIFO frame buffer with frames of data before the
3 client device sends flow control messages to request the transmission of those data frames.

1 17. The apparatus of claim 9, wherein
2 the first and second link cards each include an inbound FIFO frame buffer for storing
3 frames sent by the client device to the link card and an outbound FIFO frame buffer for
4 storing frames sent by another device to the link card for transmission to the client device;
5 and
6 the first and second link cards each store data into the inbound FIFO frame buffer and
7 read data from the outbound FIFO frame buffer at a first clock rate associated with the client
8 device, and read data the inbound FIFO frame buffer for transmission to the first multiplexer
9 unit and store data received from the multiplexer unit into the outbound FIFO frame buffer at
10 a second clock rate associated with the link card, whereby the data stream sent and received
11 to and from the client device is retimed from the first clock rate to the second clock rate.

1 18. The apparatus of claim 17, wherein the first and second data streams sent and received
2 to and from the client device are Fibre Channel data streams, the first clock rate is
3 approximately 1.0625 Gbps, and the second clock rate is at least 1.25 Gbps.

1 19. The apparatus of claim 17, wherein the first multiplexer unit includes a smoothing
2 circuit that retimes the first data stream sent from the client device from the second clock rate
3 to a third clock rate associated with the first multiplexer unit, the first multiplexer unit

- 4 transmitting the first data stream over one of the first and second optical fiber cables at the
- 5 third clock rate.